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# Deposition of Sulfur on Ag(100) Observed by a Scanning Tunneling Microscope

Dennis Vaughn[1], Margaret Hicks[1], Mingmin Shen[2], Selena Russel[2], Chad Yuen[2],
Dapend Jing[2], Alex Belianinov[2], Baris Unal[2], Patricia Thiel[3] and Cynthia Jenks[4]
1- Teahcer-intern, Ames Lab, ACTS DOE Program, 2- Graduate Student, Iowa State University,
3- Professor, Iowa State University, 4- Assistant Director of Scientific Planning, Ames Lab

## ABSTRACT

In this experiment we studied the deposition of sulfur molecules onto the surface of silver (Ag) metal with a specific atomic pattern called Ag(100). The Scanning Tunneling Microscope enabled us to scan a sample of silver to determine the arrangement of atoms, verify the removal of oxides from the surface, and to examine the deposition of sulfur onto the surface.

## BACKGROUND

In 1981 the Scanning Tunneling Microscope was invented by Gerd Binning and Heinrich Rohrer. The STM is used to obtain atomic-scale images of metal surfaces. It provides a three-dimensional profile of the surface which is very useful for determining the size and location of atoms. Current flows from the electron tip to the surface in a very low pressure vacuum (Figure 1) resulting in an extremely accurate topography of the surface. This allows scientist to study the roughness of the surface, observe surface defects and analyze the deposition of other atoms onto the surface. Consider the size of the atoms in which the STM is able to detect. A nanometer is one billionth of a meter ($1 \times 10^{-9}$) and 3 atoms represent the distance of one nanometer. (Figure 2)

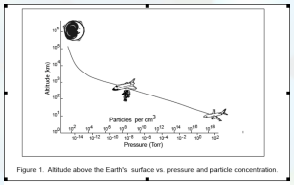

Figure 1. Altitude above the Earth's surface vs. pressure and particle concentration.

Figure 1

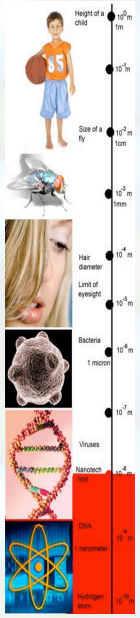


Figure 2

## RESEARCH QUESTION/HYPOTHESIS

To determine the resulting arrangement of atoms of sulfur on Ag(100) following deposition of sulfur vapor onto the surface of silver under low pressure.

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## METHODS

After polishing a 2 mm X 6 mm piece of pure silver, the sample was placed in the STM for cleaning. During this process called sputtering, Argon ions are sprayed at the surface of the metal to remove oxides. Following sputtering the metal is heated to 800 Kelvin using a high voltage electric current in a process known as annealing, allowing the molecules to increase movement and "fill" and deviations in the arrangement of atoms. After numerous attempts to clean the silver in this manner, the surface was finally ready for the deposition of Sulfur. The sulfur was heated to a temperature above its boiling point to make sulfur vapor and introduced into the chamber allowing some of the sulfur molecules to land on the surface of the silver. A three-dimensional profile of the bonding of the sulfur molecules onto the Ag(100) surface was graphically displayed by the computer by detecting the flow of electrons from the tip of the STM to the specific surface location. (Figure 3)

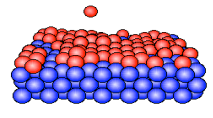
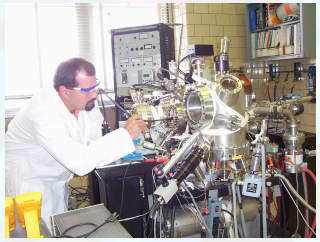


Figure 3



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## RESULTS

After cleaning the Ag(100) surface by sputtering and annealing for several days the metal was finally ready for sulfur deposit. Figure 4 illustrates the surface of Ag(100) before it was cleaned properly for depositing. The peaks show the presence of oxides and other contaminates. Figure 5 is Ag(100) after sputtering and annealing with a surface nearly free of contaminates and deviations while Figure 7 is a view after sulfur deposition. Finally, Figure 7 illustrates the deposition of sulfur molecules from a two dimensional perspective illustrating the sulfur atoms on the four fold hallow sites of the silver.

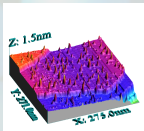

Figure 4

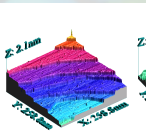

Figure 5

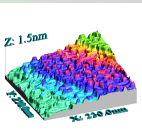

Figure 6

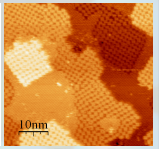

Figure 7

## DISCUSSION

From investigations with other metals with a (100) atom arrangement it was determined that sulfur would be deposited in the four fold sites of the surface. In this experiment we found the same results with the sulfur atoms forming a near monolayer of atoms after bonding at the four fold sites. Test with LEED (Low Energy Electron Diffusion) and Auger Electron Spectroscopy are needed for future investigations

## REFERENCES

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